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DETAILED REPORT

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(Name of invention)
contact printing method, contact printing device, and printing mold

Abstract
(Object)
The object of this invention is to offer a printing mold which has excellent adhesion. The object is also to offer a contact printing method and contact printing device which can form large high definition cell walls with satisfactory quality by a simple method using the mold in this invention.

(Solution)

This invention consists of a contact printing method and contact printing device which uses a three layer printing mold which consists of a reinforcing layer, a cushion layer, and a mold layer. It also includes an adhesion process which increases the adhesive contact area in the direction perpendicular to the cell walls; a release process which releases from one end to other end or from both ends to the center while forming a linear release boundary perpendicular to the cell wall direction by warping the printing mold.

Sphere of patent request

(claim 1) Claim 1 is regarding a sheet type printing mold which has a concave part which forms the cell walls and is plastic enough to follow unevenness on the substrate.

(claim 2) Claim 2 is regarding the printing mold in claim 1 where the main material is metal which is 200 µm to 3 mm thick.

(claim 3) Claim 3 is regarding the printing mold in claims 1 and 2 where the printing mold has a reinforcing layer and a cushion layer.

(claim 4) Claim 4 is a contact printing method with the following characteristics: the concave parts of a printing mold are filled with cell wall material, an adhesion process is used to attach the printing mold to the substrate where the cell walls will be formed; a curing process which cures the cell wall material in the printing mold and then fixes it on the substrate; a release process which releases the printing mold and leaves the cell wall material in a predetermined shape on the substrate, the printing mold is a sheet-type mold which has concave parts in the shape of the cell walls which is also plastic enough to follow unevenness on the substrate.

(claim 5)

In the contact printing method in claim 4, claim 5 is regarding a contact printing method which has the following characteristics: the adhesion process bonds part of the printing mold to the substrate and initially forms a linear adhesion area at right angles to the lengthwise direction of the cell walls. The adhesion area is then widened in a direction parallel to the lengthwise direction of the cell walls.

(claim 6)

In the contact printing method in claim 5, claim 6 is regarding a contact printing method where the adhesion process applies pressure by using a roller.

(claim 7)

In the contact printing method in claim 4 to 6, claim 7 is regarding a contact printing method where the adhesion process attaches the printing mold and the substrate while the cell wall material is cured during the curing process. After this, the cell wall material is fixed on the substrate.

(claim 8)

In the contact printing method in claim 7, claim 8 is regarding a contact printing method which has the following characteristics: Attachment by adhesion is performed by applying pressure to the back surface, i.e. the surface opposite the printing mold. The back pressure process uses a pressure-diffusing part which reduces pressure deviations (deviation of pressure at each position on the back surface).

(claim 9)

In the contact printing method in claims 4 to 8, claim 9 is regarding a contact printing method where the release process warps the printing mold and forms a linear release boundary perpendicular to the lengthwise direction of cell walls. It also releases from one end to other end in a direction parallel to the lengthwise direction of the cell walls while warping the printing mold. It may also move the release boundary from both ends to the center.

(claim 10)

In the contact printing method in claim 9, claim 10 is regarding a contact printing method where the release process releases uses a roller guide at the release boundary.

(claim 11)

Claim 11 is regarding a contact printing device which has the following characteristics: the concave parts of a printing mold are filled with cell wall material, an adhesion process is used to attach the printing mold to the substrate where the cell walls will be formed; a curing process which cures the cell wall material in the printing mold and then fixes it on the substrate; a release process which releases the printing mold and leaves the cell wall material in a predetermined shape on the substrate, the printing mold is a sheet-type mold which has concave parts in the shape of the cell walls which is also plastic enough to follow unevenness on the substrate.

(claim 12)

In the contact printing device in claim 11, claim 12 is regarding a contact printing device which has the following characteristics: The adhesion step attaches part of the printing mold to the substrate and initially forms a linear adhesion area at right angles to the lengthwise direction of the cell walls. The adhesion area is then widened in a direction parallel to the lengthwise direction the cell parting walls.

(claim 13)

In the contact printing device in claim 11, claim 13 is regarding a contact printing device where the adhesion step uses a pressure roller.

(claim 14)

In the contact printing device in claims 11 to 13, claim 14 is regarding a contact printing device where the adhesion process attaches the printing mold to the substrate during the time that the cell wall material is cured. The cell walls are then fixed on the substrate.

(claim 15)

In the contact printing device in claim 14, claim 15 is regarding a contact printing device which has the following characteristics: Adhesion is performed by applying pressure to the back surface. i.e. the surface opposite from the printing mold. The back pressure process uses a pressure-diffusing part which reduces pressure deviation (deviation of pressure at each position on back surface).

(claim 16)

In the contact printing device in claim 15, claim 16 is regarding a contact printing device which has the following characteristics: The adhesion step has a belt, rollers, a roller support, an air cylinder, and a moving stage. The belt is an elastic loop which is plastic enough to serve as the pressure diffuser. The rollers are flat, and their axes are placed in parallel. Also, the rollers run the belt and keep it flat. The roller support supports the multiple rollers so they can be rotated. The air cylinder moves the roller support from a position where it applies pressure to the back surface of the printing mold to an escape position which at a distance from the back surface. The moving stage supports the roller support so that it can be moved parallel to the lengthwise direction of the cell walls in the printing mold.

(claim 17)

In the contact printing device in claim 15, claim 17 is regarding a contact printing device which has the following characteristics: The adhesion step has back-up rollers, a belt, a roller support, an adhesion roller, a moving stage, and an air bag. The back-up rollers are flat, and their axes are placed in parallel. The belt is a loop belt which runs on the back up rollers and is held flat. The roller support supports the back-up rollers so they can be rotated. The adhesion roller bonds the printing mold prior to the belt and forms the initial adhesion area. At the same time, it controls the expanded area of the air bag. The moving stage supports the roller support and adhesion roller and moves parallel to the lengthwise direction of the cell wall printing mold. The air bag is the pressure diffusing part, and covers the back surface of the printing mold. It does not apply pressure to the non-expansion area on the front side of the adhesion roller. The area of the rear side of the adhesion roller is expanded using pressurized gas, and it applies pressure to the printing mold which is supported on the back by the backup rollers.

(claim 18)

In the contact printing device in claims 11 to 17, claim 18 is regarding a contact printing device which has the following characteristics: The release process warps the printing mold and forms a linear release boundary perpendicular to the lengthwise direction of the cell walls. It releases from one end to other end parallel to the lengthwise direction of the cell walls by warping the printing mold. It may also move the release boundary from both ends to the center.

(claim 19)

In the contact printing device in claim 18, claim 19 is regarding a contact printing device where the release uses a guide roller at the release boundary.

Detailed explanation of the invention

[0001]

(Field of industrial use)

This invention is regarding the technical field of contact printing. Especially, it is regarding a printing mold for forming cell walls for a plasma display panel, a contact printing method, and a contact printing device.

[0002]
(Prior art)

Plasma display panels (called PDP in the following) are generally considered to be large screen display devices which are thinner, lighter, more vivid, and have a wider viewing angle than a liquid crystal panel. Generally, PDP have one pair of electrodes which are regularly arranged between two facing glass substrates. A gas which is mainly neon or xenon is enclosed between them. Voltage is applied between these electrodes, and an electric discharge is started in tiny cells around the electrodes. This illuminates each cell to make a display. For displaying pictures, cells are regularly arranged and are selectively illuminated.

[0003] At this point, the construction of an AC model PDP is going to be explained as one example. The construction of an AC model PDP is indicated in figure 7. As shown in figure 7, two glass substrates 710, 720 are placed facing each other. These two glass substrates 710, 720 are normally keep at a fixed distance by cell walls (called cell walls or ribs) which are set up in parallel on a glass substrate 720 which will become the back board.

[0004] The back side of a glass substrate 710 has parallel transparent composite electrodes 740 which maintain the discharge and metal electrodes 750 which are the base electrodes. A derivative layer 760 covers these electrodes. A protective layer of MgO 770 is set up on top of this. In addition, the front side of the glass substrate 720 has parallel address electrodes 780 perpendicular to the composite electrodes. Furthermore, a fluorescent surface 790 covers the surface of the cell walls 730 and the bottom surface. The cell walls 730 determine the discharge space, and each discharge space is called either a cell or a light-emitting unit area.

[0005] This AC model PDP is a surface discharge model, and a discharge is produced by applying alternating voltage between the composite electrodes on the front board. UV generated by this electric discharge illuminates the fluorescent material 790, and this light forms a display which is transmitted to the front board. In a DC type PDP, the electrodes differ from that of the AC model in the point that the electrode structure is not covered by a derivative layer. However, the principle that the display is formed by light emitted by an electric discharge is the same. The one shown in figure 7 has a foundation layer 767 on one surface of the glass substrate 720 and a derivative layer 765 on top of that. However, the foundation layer 767 and derivative layer 765 are not particularly necessary.

[0006] Former methods of forming method cell walls on the glass substrate 720 include printing or sand blasting. In the printing method, paste for forming cell walls is printed on the glass substrate in a predetermined pattern by a thick-film printing method and dried. The film thickness of the cell wall is relatively thick (for example, 100 to 200 μm). Since this film thickness cannot be acquired in a single printing, printing and drying of the paste for forming cell walls are repeated multiple times. After a predetermined film thickness is acquired, the paste is sintered. In the sand blasting method, cell wall materials are first applied to a glass substrate. After a predetermined resist pattern is formed on top of this, abrasive is used to remove part of the cell wall material. After sintering this, cell walls are formed.

[0007]

(Problems that this invention tries to solve)

However, in the printing method, the repeated process steps are troublesome, and the cell walls formed are not uniform. In the sand blasting method, there are problems with uniformity of the abrasive, dust, and maintenance of the processing equipment (abrasive, etc.) is difficult. A method which can easily form large, high definition parts such as cell walls for a PDP with satisfactory quality is needed.

[0008] There has been a suggestion to form cell walls by contact printing methods. Contact printing methods use a sheet-type printing mold which has concave parts in the shape of the cell walls. First the concave parts are filled with cell wall material. Next, printing material is adhered onto a glass substrate. After it is cured and fixed, printing materials in the shape of the cell walls is printed on a glass substrate. After sintering, cell walls are formed.

[0009] In this contact printing method, printing is done by adhesion. Needless to say, bonding between the printing mold and glass substrate during printing is extremely important. If a flat glass substrate with a polished surface is used, bonding will not be a major problem. However, considering cost, conventional floating glass which does not have superior flatness or thickness accuracy is preferred. In addition, when sintering or annealing is performed before adhesion-printing, warping of the glass substrate may occur.

[0010] This invention has been made in order to solve these problems. Its object is to offer a printing mold with excellent adhesion and to offer a method of easily forming large, high definition parts such as cell walls for a PDP with satisfactory quality using the mold.

[0011]

(Steps for solution)

The above problems are solved by this invention as described in the following. That is, the printing mold in claim 1 of this invention is a sheet-type mold which has concave areas for forming cell walls. It is also plastic enough to follow unevenness on the substrate. In this invention, since the printing mold is plastic enough to follow unevenness on the substrate, adhesion is especially excellent. The printing mold in claim 2 of this invention, as stated in claim 1, is mainly made of metal which is 200 μm to 3 mm thick. This invention supplies a pliable mold which can follow unevenness on the substrate. This printing mold also which will not be destroyed by forces associated with the release process. The printing mold in claim 3 of this invention is similar to the printing mold in claims 1 and 2. It has a reinforcing layer and a cushion layer. In this invention, a superior printing mold can be acquired which is plastic enough to follow unevenness of the substrate and strong enough to withstand forces associated with the release process as stated above.

[0012] The contact printing method in claim 4 of this invention has the following characteristics: the concave parts of a printing mold are filled with cell wall material, an adhesion process is used to attach the printing mold to the substrate where the cell walls will be formed; a curing process which cures the cell wall material in the printing mold and then fixes it on the substrate; a release process which releases the printing mold and leaves the cell wall material in a predetermined shape on the substrate, the printing mold is a sheet-type mold which has concave parts in the shape of the cell walls which is also

plastic enough to follow unevenness on the substrate. In this invention, since the printing mold is plastic enough to follow unevenness of the substrate, it can be used to easily form large, high definition parts with satisfactory quality. The contact printing method in claim 5 of this invention is similar to claims 4 and 5. It has the following characteristic: the adhesion process bonds part of the printing mold to the substrate and forms an initial adhesion area in linear shape at right angles to the lengthwise direction of the cell walls. The adhesion area is then widened in a direction parallel to the lengthwise direction of the cell walls. In this invention, part of the printing mold is bonded to the substrate at right angles to the lengthwise direction of the cell walls to form a partially complete adhesion area initially. After that, the adhesion area is widened. Accordingly, it will entrap gas, and the complete adhesion area can be formed as a whole. The contact printing method in claim 6 of this invention is similar to the contact printing method in claim 5. The adhesion process uses a pressure roller. Accordingly, it will not entrap gas, and the completely adhesion area as a whole can be formed even better. The contact printing method in claim 7 of this invention is similar to the contact printing method in claims 4 to 6. The adhesion process attaches the printing mold and the substrate during the time that the cell wall material is cured. Then it is fixed on the substrate. In this invention, extremely good adhesion can be obtained during the curing process, and it is possible to make an extremely strong bond between the cured cell wall material and the substrate. The contact printing method in claim 8 of this invention is similar to the contact printing method in claim 7. Adhesion is secured by applying pressure to the back face pressure (the surface opposite from the printing mold). The back surface pressure process uses a pressure-diffusing part which reduces pressure deviation (deviation of pressure at each position on back surface). This invention uses a pressure diffusing part to reduce pressure deviation during the back pressure process. Accordingly, very good adhesion is obtained over the entire surface of the printing mold, and it is possible to make an extremely strong bond between the cured cell wall material and the substrate. The contact printing method in claim 9 is similar to the contact printing method in claims 4 to 8. The release process warps the printing mold and forms a linear release boundary perpendicular to the lengthwise direction of the cell walls. It releases from one end to the other parallel to the lengthwise direction of the cell walls while warping the printing mold. It may also release by moving the release boundary from both ends to the center. In this invention, a linear release boundary is formed at right angles to the lengthwise direction of the cell walls by warping the printing mold. Releasing is done from one end to the other, or from both ends to the center. In other words, this minimizes the force on the printing mold or cell walls so that the printing mold and cell walls will not be destroyed. In addition, the cell walls can remain fixed to the glass substrate. Accordingly, complete releasing can be done easily. The contact printing method in claim 10 of this invention is similar to the contact printing method in claim 9. In addition to the above, the release process uses a guide roller. Therefore, complete releasing can be done more easily and more completely as a whole.

[0013] The contact printing device in claim 11 is regarding a contact printing device which has the following characteristics: the concave parts of a printing mold are filled with cell wall material, an adhesion process is used to attach the printing mold to the substrate where the cell walls will be formed; a curing process which cures the cell wall material in the printing mold and then fixes it on the substrate; a release process which

releases the printing mold and leaves the cell wall material in a predetermined shape on the substrate, the printing mold is a sheet-type mold which has concave parts in the shape of the cell walls which is also plastic enough to follow unevenness on the substrate. In this invention, since the printing mold is plastic enough to follow unevenness on the substrate, it can form large, high definition parts with satisfactory quality easily. The contact printing device in claim 12 of this invention is similar to the contact printing device in claims 11 and 12. The adhesion step attaches part of the printing mold to the substrate and initially forms a linear adhesion area perpendicular to the lengthwise direction of the cell walls. The adhesion area is then widened parallel to the lengthwise direction of the cell walls. In this invention, part of printing mold is adhered to the substrate in a linear shape perpendicular to the lengthwise direction of the cell walls. A partially complete adhesion area appears at first, and the adhesion area is widened after that. Accordingly, the complete adhesion area can be formed without entrapping gas. The contact printing device in claim 13 of this invention is similar to the contact printing device in claim 11. The adhesion step uses a pressure roller. Therefore, without entrapping gas, a complete adhesion area can be formed. The contact printing device in claim 14 of this invention has is similar to the contact printing device in claims 11 to 13. The adhesion step attaches the printing mold to the substrate during the time that the cell wall material is cured. It is then fixed on the substrate. In this invention, extremely good adhesion is obtained during the curing process, and it is possible to make the adhesion between the cured cell wall material and the substrate extremely strong. The contact printing device in claim 15 of this invention is similar to the contact printing device in claim 14. Adhesion is secured by applying back pressure to the surface opposite from the printing mold. This back surface pressure process uses a pressure-diffusing part which reduces pressure deviation (deviation of pressure at each position on back surface). Therefore, extremely good adhesion can be obtained over the entire surface of the printing mold, and it is possible to make adhesion between the cured cell wall materials and the substrate extremely strong. The contact printing device in claim 16 of this invention is similar to the contact printing device in claim 15. The adhesion step has a belt, rollers, a roller support, an air cylinder, and a moving stage. The belt is an elastic loop which is plastic enough to serve as the pressure diffuser. The rollers are flat, and their axes are placed in parallel. Also, the rollers run the belt and keep it flat. The roller support supports the multiple rollers so they can be rotated. The air cylinder moves the roller support from a position where it applies pressure to the back surface of the printing mold to an escape position which at a distance from the back surface. The moving stage supports the roller support so that it can be moved parallel to the lengthwise direction of the cell walls in the printing mold. In this invention, because the adhesion step uses an elastic loop belt with plasticity as a pressure diffusing part, extremely good adhesion state is obtained over the entire surface of the printing mold. The contact printing device in claim 17 of this invention is similar to the contact printing device in claim 15. The adhesion step has back-up rollers, a belt, a roller support, an adhesion roller, a moving stage, and an air bag. The back-up rollers are flat, and their axes are placed in parallel. The belt is a loop belt which runs on the back up rollers and is held flat. The roller support supports the back-up rollers so they can be rotated. The adhesion roller bonds the printing mold prior to the belt and forms the initial adhesion area. At the same time, it controls the expanded area of the air bag. The moving stage supports the roller support

and adhesion roller and moves parallel to the lengthwise direction of the cell wall printing mold. The air bag is the pressure diffusing part, and covers the back surface of the printing mold. It does not apply pressure to the non-expansion area on the front side of the adhesion roller. The area of the rear side of the adhesion roller is expanded using pressurized gas, and it applies pressure to the printing mold which is supported on the back by the backup rollers. In this invention, the adhesion step which uses the air bag as the pressure diffuser to form an expanded area by introducing pressurized gas, extremely good adhesion is obtained over the entire surface of the printing mold. The contact printing device in claim 18 of this invention is similar to the contact printing device in claims 11 to 17. The release process warps the printing mold and forms a linear release boundary perpendicular to the lengthwise direction of the cell walls. It releases from one end to the other parallel to the lengthwise direction of the cell walls while warping the printing mold. It may also release by moving the releasing boundary from both ends to the center. In this invention, a linear release boundary is formed at right angles to the lengthwise direction of the cell walls by warping the printing mold. Releasing is done from one end to the other, or from both ends to the center. That is, force on the printing mold or cell walls is minimized, and the printing mold and cell walls will not be destroyed. The cell walls can remain fixed to the glass substrate. Therefore, complete releasing can be done easily. The contact printing device in claim 19 of this invention is similar to the contact printing device in claim 18. The release step uses a guide roller at the release boundary. Accordingly, complete releasing can be done more easily and more completely as a whole.

[0014]
(Embodiment of this invention)

Next, the embodiment of this invention is going to be explained. This invention includes a contact printing method, a contact printing device, and a printing mold which is suitable for the method and the device. The printing mold of this invention is going to be explained first. After that, the contact printing method and contact printing device are going to be explained. One example of the printing mold of this invention is shown in figure 1. In figure 1, 101 is a reinforcing layer; 102 is a cushion layer; 103 is the main mold body; 104 is a concave part for forming cell walls. The printing mold of this invention has concave parts 104 for forming cell walls which are filled with cell wall material. The mold is first filled, and then the filled side is adhered to the substrate. The printing mold in figure 1 is one example which has a three-layer structure. The printing mold of this invention can be a single layer. A single layer printing mold has only the main part of the mold 103 in figure 1. First, a single layer printing mold of single layer is going to be explained. After that, the three-layer printing mold shown in figure 1 is going to be explained.

[0015] In the single layer printing mold, the mold better if it is thinner so that it can follow the unevenness of the substrate. This is also better at adhesion and releasing, in order to prevent plastic deformation of the printing mold when the printing mold is warped. However, if it is too thin, pulling the end of the printing mold during releasing can cause local plastic deformation in actual use. A single layer printing mold requires a thickness which balances these factors.

[0016] In the three-layer printing mold shown in figure 1, when the main body of the mold 103 is thinner, it will follow the to unevenness on the substrate better. However, outside forces during adhesion and releasing influence the main mold body 103, and there are cases when the main mold body 103 is plastically deformed. By using a reinforcing layer 101, that is, laminating the main mold 103 and reinforcing material, the outside forces are dispersed in the reinforcing layer 101, and the main mold body 103 is not likely to be plastically deformed. However, if the reinforcing layer 101 and main mold body 103 are simply pasted together strongly, it will not follow the unevenness on the substrate as well. Because of this, a cushion layer 102 should be set up between the reinforcing layer 101 and the main mold body 103.
[0017] The physical features of the printing mold (or main mold body 103) for adhesion printing when the printing mold (or main mold body 103) is manufactured by electric casting (one example of the manufacturing method will be explained later) are indicated in table 1.

Table 1

Plating thickness	Following substrate (printing errors)	Deformation of mold due to bending
200 μm	O	X (single layer mold) O (three layer mold)
500 μm	O	X (single layer mold) O (three layer mold)
1 mm	O	O
2 mm	O	O
3 mm	O~Δ	O~Δ
4 mm	X (concave part is bad)	X (Plastic deformation occurs)

[0018] As is obvious from the results of the example of practice shown in table 1 above, a mold made of metal (electric casting mold) and 20 μm to 3 mm thickness will produce good results. It will follow the substrate during contact printing and during bending of the mold, etc. A printing mold which has a reinforcing layer 101 and a cushion layer 102 produces even better results as far as follow the substrate during contact printing and during bending, etc.
[0019] Next, one example of a manufacturing method for a printing mold or main mold body 103 of this invention is going to be explained based on figure 2. First, as shown in figure 2(a), a light-shielding thin film (pattern) 220 is formed in a predetermined shape corresponding to the shape of the concave part. This light-shielding thin film 220 can be a metal thin film, an organic thin film, light-shielding paint, etc. It can be formed, for example, by forming resist in a predetermined shape on one surface of a base substrate and then silver coating the entire surface of the resist by a silver mirror reaction and then removing the resist. A light-shielding thin film can also be formed on one surface of a base substrate using vapor-deposition or sputtering. The resist is then applied in a predetermined shape on top of that in photolithography methods. Next, the resist forms an etching-proof mask, and the light-shielding thin film is etched. After removing the

resist, the light-shielding thin film pattern 220 shown in figure 2(a) can be acquired. Alternately, the base substrate itself can be etched to form grooves corresponding to a predetermined shape. Light shielding anti-pharmaceutical paint is used to fill the grooves, and the light-shielding thin film pattern 220 shown in figure 2(a) can be acquired.

[0020] Next, as shown in figure 2(b), the entire surface with the light-shielding thin film pattern 220 on the base substrate 210 is covered, and a negative type photo-sensitive resist layer 240 is arranged with a thickness equivalent to the depth of the concave part. Next, as shown in figure 2(c), ionizing radiation 250 is used to irradiate the entire surface from the back side which is not covered by the photo-sensitive resist layer 240 on the base substrate 210. Then the photo-sensitive resist 240 is exposed to light through openings in the light-shielding thin film pattern 220 and cured. Next, as shown in figure 2 (d), the photo-sensitive resist 240 is developed, and a light-shielding pattern 220 (cured part 240A) of photo-sensitive resist is acquired in a predetermined shape.

[0021] As long as the photo-sensitive resist 240 can be used to form the concave part, it is not limited specifically. In other words, any one which can acquire a thickness equivalent to the depth of the concave part and also has good plating-releasing performance and image-decomposing performance can be used. For example, when the cell wall thickness of 100 to 200 μm for a plasma display panel (PDP) is desired, resist such as dry film resist (manufactured by Dupont MRC Dry Film K.K., FRA-517-50, or manufactured by Nichigo Morton K.K., NIT-650, etc.) can be used.

[0022] Next, as shown in figure 2(e), an electrically conductive thin film 270 is formed covering the cured part 240A of the photo-sensitive resist and the light-shielding thin film 220. This electric conductive thin film 270 can be formed by using an activation process for performing electroless plating on the cured part 240A of the photo-sensitive resist and the exposed part 9 of the light-shielding thin film 220, electroless plating is performed. Although electroless plating is desired, this invention is not limited to only this process. Next, as shown in figure 2(f), electrolytic plating is performed on conductive thin film 270. Next, as shown in figure 2(g), after releasing the electrolytic plating layer 280 and conductive thin film 270 from the light-shielding thin film 220, the base substrate 210 and cured part 240A of photo-sensitive resist formed on top of that, a printing mold which consists of an electrolytic plating layer 280 and conductive thin film 270 is acquired.

[0023] As stated above, the printing mold which consists of an electrolytic plating layer 280 and conductive thin film 2 acquired by releasing can be used as it is. If necessary, a mold release treatment for improving printing performance or curing treatment for improving durability can be used. A mold release treatment and curing treatment in this case are done on the surface of the electrolytic plating layer 280 after the conductive thin film 270 is removed from the electrolytic plating layer 280. Specifically, electroless plating impregnated with PTFE (polytetrafluoroethylene) is listed as a mold release treatment. Hard Cr plating is listed as a curing treatment. However, this invention is not limited to these examples only.

[0024] Next, the contact printing method and contact printing device of this invention are going to be explained. One example of the contact printing device of this invention is shown in figure 3. In figure 3, 301 is a work stand, 302 is an adhered part stand, 303 is a glass disk, 304 is a light source, 305 is a camera for detecting position, 306 is a

positioning structure, 307 is an adhering roller, 320 is a glass substrate, 321 is a printing mold edge.
[0025] The work stand 301 supports a glass substrate 320 which constitutes a PDP. The glass substrate 320 is placed on a glass disk 303 which has been placed on top of the work stand 301. This glass disk 303 is used because photo-curing type cell wall materials can be used. When the cell wall material is not photo-curing, such as a two-part curing type, it is possible to use an opaque disk. As shown in figure 4, the work stand 301 has a light source 304 on the opposite side from the glass disk 303 with the glass substrate 320. Light from the light source 304 is transmitted through the glass disk 320 to the glass substrate 320. Next, it is transmitted by the glass substrate 320 to expose the cell wall material.
[0026] The glass substrate 320 already has an electrode layer and derivative layer. A favorable example uses a sintered electrode layer that is free of organic material. The derivative layer remains un-sintered in order to remain elastic and correct printing such as plastic deformation, Simultaneous sintering of the derivative layer and cell wall layer is performed after forming the cell walls. However, the electrode layer is also un-sintered, and the process can be shortened even more sintering the three layers at the same time.
[0027] The work stand 301 also has a camera for detection position 305 and a positioning structure 306 for positioning the glass substrate 320 and printing mold. In the example shown in figure 1, the substrate 320 is fixed to the glass disk 303, and the positioning structure 306 moves the printing mold. In other words, the glass disk 303 has a structure (not shown in figure) which fixes the glass substrate 320. This structure can be a vacuum device, a structure which contacts the edge of the glass substrate 320, or a clamp which clamps the edge of the glass substrate 320, etc.
[0028] One end of the printing mold is supported by this positioning structure 306. When the positioning structure 306 is moved, this movement is transmitted to the printing mold from its supported edge. The camera for detecting position 305 photographs multiple positioning marks on the surface of the glass substrate 320 and printing mold through the glass disk 303. Based on the photographed image of these marks, positioning errors at each mark are calculated by a data processing section (not shown in the figure). To minimize positioning errors at each spot, the necessary correction is calculated by the data processing section. The positioning structure 306 inputs the desired correction, and the position (x, y, θ) is corrected by the positioning structure 306.
[0029] The part stand 302 has a structure which presses and adheres the glass substrate 320 on the work stand 301 to the printing mold. In figure 1, an adhesion roller 307 is shown as one example. This adhesion roller 307 can be raised and lowered independently, and it has a rubber surface. For example, appropriate pressure can be attained with 40 degree rubber hardness, 100 mmϕ roller diameter, 102 mm roller pitch, and 0.5 to 5 kgw/cm pressure. However, this invention is not limited to only these examples.
[0030] The adhesion roller 307 is moved by a rail (not shown in figure) set up on the work stand. During adhesion, the adhesion roller 307 moves as a unit and starts to adhere the printing mold on glass substrate 320 by moving forward. When adhesion is complete, it supports the printing mold and glass substrate 320 as a unit. During the

releasing process, the edge of the printing mold which is not supported by the positioning structure 306 is pulled up by a machine device (not shown in the figure) while the adhesion roller 307 moves in the opposite direction. A releasing line is maintained between the printing mold and substrate 320, and the releasing speed can be maintained at a fixed rate.

[0031] Using this example of construction, the movements of the contact printing device in this invention are going to be explained. The motion of the contact printing device in this invention is shown in figures 4(A) to 4(D). Cell wall material is used to fill the concave areas of the printing mold in a step which is not shown in the figure. The printing mold and glass substrate 320 are placed on the work stand 301. In other words, the printing mold is supported by the positioning structure 306, and the glass substrate 320 is fixed on the glass disk 303. The surface with the cell wall material and the surface of the glass substrate 320 face each other.

[0032] Figure 4(A) shows this state. As shown in figure 4(A), the printing mold and glass substrate 320 are set facing each other and almost parallel. One edge of the printing mold is supported by the positioning structure 306 as stated above. The other edge of the printing mold is supported by an edge support (not shown in the figure). The positioning marks are photographed by the camera for detecting position 305, and a series of motions for positioning the printing mold and glass substrate 320 are performed. In figure 4(A), the printing mold and glass substrate 320 are set facing each other and almost parallel. However, when the positioning marks are near the edge supported by the positioning structure 306 only, the other edge of the printing mold can be placed in the upper position.

[0033] After this preparation, the adhesion motion is started. The first step is that the adhesion roller 307 is moved as a unit so that the adhesion roller 307 will be positioned on top of one edge of the printing mold. Then, the adhesion roller 307 is lowered to apply pressure to the section near the edge of the printing mold which is supported by the positioning structure 306, and the printing mold and glass substrate 320 are partially adhered. During this first step of the adhesion process, part of the printing mold is adhered to the substrate, and an initial linear adhesion area is formed at right angles to the lengthwise direction of the cell walls. Figure 4(B) shows the completion of the first step of the adhesion process.

[0034] Next the adhesion motion widens the bonded area in a direction parallel to the lengthwise direction of the cell walls. Figure 4 (C) shows the middle of this next step of the adhesion process. The adhesion roller 307 is moved further as a unit, at the same time, the adhesion rollers which reached the upper side of the printing mold are lowered in order from the inside out. The adhesion area is widened, at the same time, adhesion in the area which has been already adhered is maintained. In addition, as the adhesion roller 307 moves, the other edge of the printing mold is lowered by the support structure. Figure (D) shows the adhesion process after adhesion between the printing mold and glass substrate 320 has been completed.

[0035] The motion of the contact printing device in this invention is going to be explained further in the following. The next motion of the contact printing device is to energize the light source 304 to expose the cell wall material in the completely adhered state as shown in figure 4(D). By this step, the cell wall material is cured on the glass substrate. During this curing process, the adhesion process continues, and adhesion

between the printing mold and substrate is secured from the adhesion to the curing process. This makes the adhesion between the cured cell wall material and the substrate very strong.
[0036] Next, the contact printing device performs a motion which is the reverse of the above adhesion process. That is, release is done in the order shown by figures 4 (D)-(C)-(B)-(A). (release process) This release process warps the printing mold and forms a linear release boundary perpendicular to the lengthwise direction of the cell walls. It releases from one end to other parallel to the lengthwise direction of the cell walls while warping the printing mold. It may also release by moving the releasing boundary from both ends to the center. Releasing is done in order by using a guide roller at the release boundary. In the example of construction of a contact printing device is shown in figure 4, releasing is performed from one edge to other. However, it can be constructed so that it releases from both ends to the center.
[0037] A model of the adhesion and releasing process is shown in figures 8 and 9. Based on figures 8 and 9, the adhesion process and releasing process are going to be explained for easier understanding. In figures 8 and 9, 801 is a printing mold which has been filled; 802 is a substrate to be printed; 803 is the initial adhesion area; 804 is the adhesion area in the process of being enlarged; 805 is the final adhesion area; 806 is a linear release boundary; 807 is the finished cell walls. At first, as shown in ① in figure 8, part of the printing mold which has been filled 801 and substrate to be printed 802 are attached to form an initial adhesion area 803. This initial adhesion area 803 is a linear area at right angles to the lengthwise direction of the cell walls.
[0038] Next, this initial adhesion area 803 is enlarged. The adhesion area 804 in the middle of the enlarging process is shown as ② in figure 8. As shown in ③ in figure 8, the entire predetermined area of the filled printing mold 801 and the substrate to be printed 802 are attached, and the adhesion process is completed.
[0039] Continuing the adhesion process, curing is performed. After curing, the a linear release boundary 806 is formed by warping the filled printing mold 801 to release part of the adhered area from the substrate to be printed 802. As shown in ④ in figure 9, as the filled printing mold 801 is bent more more, the release boundary 803 is moved. This releasing boundary 803 moves in a direction parallel to the lengthwise direction of the cell walls from one end to other or from both ends to the center. And as shown in ⑤ in figure 9, the filled printing mold 801 and substrate to be printed 802 are completely released, and the release process is finished.
[0040] In one example of adhesion process shown in figure 4 above, an adhesion roller 307 is used. This adhesion roller 307 directly contacts the printing mold, and adhesion is performed by applying pressure. At this point, the adhesion roller 307 and printing mold are in linear contact. Pressure deviation will not be minimized by applying pressure directly to the printing mold. Minimizing making pressure deviation will result in very good adhesion over the entire surface of the printing mold. In addition, by performing the curing process while maintaining the adhered condition, adhesion between the cured cell wall material and substrate can be made very strong. One example of adhesion process which can minimize pressure deviation by using pressure diffusing material is going to be explained next.
[0041] One example of a contact printing device which can minimize pressure deviation by adopting a pressure diffusing material (1st example) is shown in figure 10. In figure

10, 11 is a belt; 12a, 12b, 12c,--- are rollers; 13a, 13b are air cylinders; 14 is a roller support; 801 is a filled printing mold; 802 is a substrate to be printed. The belt 11 is an elastic loop belt which is plastic. It will be the pressure diffusing part. Also, as shown in figure 10, rollers 12a, 12b, 12c, --- are lined up on a flat surface, and multiple rotating axes exist parallel to each other. These rollers drive the belt 11, and they also keep the belt flat. A roller support 14 supports the rollers 12a, 12b, 12c, --- so that they can rotate freely.

[0042] Air cylinders 13a, 13b move the belt 11 to apply pressure on the back surface of the filled printing mold 801 and to an escape position some distance from the back surface by moving the roller support 14. Although not shown in figure 10, there is a moving stage. This moving stage supports the roller support 14 so the above motion will be possible. The stage moves parallel to the lengthwise direction of the cell walls in the filled printing mold 801.

[0043] Next, the motion of the contact printing device shown in figure 10 is explained. First, the moving stage is positioned right in front of (left side in figure 10) the filled printing mold 801. Air cylinders 13a, 13b move to the position for applying pressure. However, in this position, the belt 11 does not contact the filled printing mold 801. Therefore, it does not apply pressure to the filled printing mold 801. Next, the stage starts moving toward the filled printing mold 801.(to the right in figure 10) By this motion, the belt 11 contacts the printing mold 801, and it applies pressure to part of the surface of the printing mold 801. This forms an initial adhesion area between the printing mold 801 and substrate to be printed 802. Figure 10 (A) shows the state where the initial adhesion area has been formed.

[0044] After this, the stage moves further to the right in figure 10 along the printing mold 801, and the adhesion area between the printing mold 801 and substrate to be printed 802 starts to enlarge. Friction between the printing mold 801 and the belt 11 prevents sliding. The belt 11 rotates and moved as a loop around the rollers 12a, 12b, 12c,---. Figure 10(B) shows the adhesion area after it is enlarged. By enlarging the adhesion area in this way, complete adhesion can be attained without entrapping gas.

[0045] The stage continues moving to enlarge the adhesion area more. When the adhesion area covers the entire surface of the printing mold 801, it stops. Figure 10 (C) shows the state where the entire predetermined area has been bonded and the adhesion process is complete. As shown in figure 10 (C), since the belt 11 is elastic and plastic, it works as a pressure diffusing part. Since the rollers 12a, 12b, 12c, keep the belt 11 flat, it is possible to make the pressure deviation small. Because of this, very good adhesion is attained over the entire surface of the printing mold. By curing the material while maintaining the adhered condition, adhesion between the cured cell wall material and substrate can be made very strong.

[0046] Next, another example of a contact printing device which can minimize pressure deviation by adopting a pressure diffusing material (2nd example) is shown in figure 11. In figure 11, 20 is an air bag; 21 is a belt; 22a, 22b, 22c,…, are back-up rollers; 23 is an air cylinder; 24 is an adhesion roller; 801 is a filled printing mold; 802 is a substrate to be printed. The air bag 20 has a hole for introducing compressed gas. By introducing compressed gas and expanding it, the air bag 20 functions as the pressure-diffusing part. The area of the air bag 20 is determined by the adhesion roller 24. It is filled with compressed gas and expanded and placed just in front of the adhesion roller.

[0047] Also, as shown in figure 11, the back-up rollers 22a, 22b, 22c,…, are lined up in a flat surface, and multiple rotating axes are parallel to each other. These back-up rollers 22a, 22b, 22c,…, back up the air bag 20 and keep it flat.
[0048] An air cylinder 23 moves the air bag 20 to apply pressure to the back surface of printing mold 1 and to an escape position which is at a distance from the back surface by moving the adhesion roller 24. In the pressure position, the adhesion roller 24 forms a linear boundary on the air bag 20 and determines the area of the air bag 20. The amount of pressure applied by the adhesion roller 24 can be adjusted by adjusting the pressure of the compressed gas introduced to the air cylinder 23. Although not shown in figure 10, there is a moving stage. This moving stage supports the back-up rollers 22a, 22b, 22c, …, At the same time, it supports the adhesion roller so the above motion is possible. The stage moves parallel to the lengthwise direction of cell walls of the printing mold 801.
[0049] Next, the motion of contact printing device shown in figure 11 is explained. First, the stage is moved into position to starts the adhesion process (left side of figure 10). In this position, the air cylinders 13a, 13b move to the pressure position. By this movement, the adhesion roller 24 applies pressure to the air bag 20 at the right near the opening for filling with compressed gas and forms a linear enclosed boundary. The enclosed boundary divides the area of the air bag 20 into two. In this position, compressed gas is introduced to the air bag 20 through the filling opening. Compressed gas is introduced into the area on the side with the opening and is expanded. However, compressed gas is not introduced into the area on the opposite side of the opening. Next, the stage starts moving toward the printing mold 801 (to the right in figure 10). Compressed gas is introduced during this motion as well, and the air bag 20 widens the expansion area. By this motion, the air bag 20 applies pressure to part of the back surface of the printing mold 801 to form an initial adhesion area. Figure 11 (A) shows the state where this initial adhesion area has been formed.
[0050] After this, the stage moves further to the right in figure 11 along the printing mold 801 to enlarges the adhered area. The back up rollers 22a, 22b, 22c, …, back-up the air bag 20 through the belt 21 and apply pressure to the back surface of the printing mold 801. Friction between the belt 21 and the air bag 20 prevents sliding. The belt 21 is rotated as a loop around the rollers 22a, 22b, 22c,...,. Figure 11(B) shows the adhesion area after it is enlarged. By enlarging the adhesion area in this way, the complete adhesion area can be formed without entrapping gas.
[0051] The stage continues moving to enlarge the adhesion area more. When the adhesion covers the entire surface of the printing mold 801, it stops. Figure 11 (C) shows the completed adhesion process. As shown in figure 11 (C), since the air bag 20 is elastic and plastic. It functions as the pressure diffusing part. Since the rollers 22a, 22b, 22c, …, keep the air bag 20 flat through the belt 21, it is possible to make the pressure deviation small. Because of this, very good adhesion can be attained over the entire surface of the printing mold. In addition, curing the material while maintaining the adhered condition, adhesion between the cured cell wall material and the substrate can be made very strong.
[0052] Next, another example of a contact printing method and contact printing device of this invention is going to be explained. With the contact printing device shown in figure 3 above, for example, the four necessary processes - positioning, adhesion, exposing and curing, and releasing will be performed at one station. Therefore, when the cell wall materials require considerable curing time, the time in the contact printing device

becomes long. The production rate of the contact printing device is essentially lowered. Therefore, in the following example, of the four necessary processes - positioning, adhesion, exposing and curing, and releasing, at least exposing and curing is moved to another station, and the production rate is essentially improved.

[0053] Th work stand of the contact printing device in this example is shown in figure 5. The work stand in figure 5 is equivalent to the work stand 301 above. In figure 5, 501 is an adhering device (releasing device) disk; 502 is a handling plate; 503 is a seal; 511 is vacuum path a; 512 is vacuum path b; 513 is vacuum path c; 520 is a substrate to be printed; 521 is a printing mold. The adhering device (releasing device) disk 501 is equivalent to glass disk 303; the substrate to be printed 520 is equivalent to the glass substrate 320; the printing mold 521 is the printing mold. However, in the example shown in figure 3, although the glass substrate 320 is placed directly on the glass disk 303, in the example shown in figure 5, the substrate to be printed 520 is placed through the handling plate 502. Having this handling plate 502 is big difference between work stand shown in figure 5 and work stand 301.

[0054] When it is necessary to cure the material by exposing it to light, the handling plate 502 is naturally made of a transparent material such as glass. Vacuum path b and vacuum path c are equivalent to the fixture for the glass substrate 320 in the example shown in figure 3. Vacuum path c is a structure to the fix handling plate 502. In the example shown in figure 5, it is not necessary to use an adhering device (releasing device) disk 501 with transparent materials. Accordingly, there are fewer limitations concerning the fixture. In addition to the clamp shown in figure 3, it is possible to adopt a vacuum chuck which produced better flatness more easily.

[0055] First, the handling plate 502 is fixed in predetermined position on an adhering device (releasing device) disk 501 using vacuum path c. In addition, the substrate to be printed 520 is fixed in a predetermined position on the handling plate 502 using vacuum path b. Next, in the method shown in figure 3, the substrate to be printed 520 and the printing mold 521 are positioned. After this, as shown in figure 3, the substrate to be printed 520 and printing mold 521 are adhered by moving the adhesion roller 307 forward. In addition, vacuum path a is evacuated, that is, space d is evacuated, and the substrate to be printed 520 and printing mold 521 are adhered completely. At the same time, the handling plate 502, substrate to be printed 520, and printing mold 521 are fixed.

[0056] Next, the adhesion roller 307 is moved backward and pressure is released. In addition, only vacuum path c is returned to atmospheric pressure. The handling plate 502 released in a predetermined position by an adhering (releasing) disk 501, and the handling plate 502 becomes movable. Next, the handling plate 502, substrate to be printed 520, and printing mold 521 are removed from the adhesion stand 302 by air floatation, robot, etc., and they are transported to the exposing station.

[0057] Next, the exposing station is going to be explained. One example of an exposing station is shown in figure 6. As shown in figure 6, a work stand which consists of a handling plate 502, the substrate to be printed 520, and the printing mold 521 are transported from the adhesion station as a unit. While being transported, the cell wall material is exposed and cured by light from a light source. Next, this work stand is transported to the release station. The work stand is placed in the release station, and releasing can be done by the same method as in the example in figure 3. Although the

release station can have the same construction as the adhesion station, it does not require a positioning structure, adhesion maintaining structure, etc.
[0058] So far, several examples of this invention have been explained. However, this invention is not to be limited to only these examples. It can have various states based on the technical ideas in this invention. It goes without saying that they too are included in this invention. For example, the exposing station shown in figure 6 has been used as one example. However, it is possible to set up 1 with multiple individual exposing stations. Also, as shown in figure 6, equipment efficiency can be improved by deciding the total length of the exposing station in accordance with the production speed of the adhesive station or release station. In addition, for example, if a cushioning material is used on the side opposite the printed surface of the substrate side in the adhesion station, adhesion between the printing mold and substrate will be even better. The adhesion rollers, except for the first one, do not have to be rollers since adhesion and pressure maintenance are the goal. For example, it can be a bag filled with fluid. Furthermore, the mold material is metal in these examples. Other materials can be used, as long as the material has similar plasticity to metal. It must also be able to withstand the heat, force, and be manufactured with sufficient dimensional accuracy. Materials such as resin, glass fiber, ceramic, or composites of these materials including metal can be used. Also, it is possible to perform treatments to improve physical properties such as mold release by applying a mold release layer on the surface, etc.

[0059]
(Effects of this invention)

As stated above, the printing mold in claim 1 of this invention produces excellent adhesion since it is plastic enough to follow unevenness on the substrate. The printing mold in claim 2 of this invention is plastic enough to follow unevenness on the substrate, and it will not be destroyed by forces associated with releasing. The printing mold in claim 3 of this invention also is plastic enough to follow unevenness of substrate and is strong enough to withstand the forces associated with releasing.
[0060] The contact printing method in claim 4 of this invention, since the printing mold is plastic enough to follow unevenness of the substrate, can be used to form large, high definition parts with satisfactory quality. The contact printing method in claim 5 of this invention can form complete adhesion over the entire area without entrapping gas. The contact printing method in claim 6 of this invention can form complete adhesion more perfectly without entrapping gas. The contact printing method in claim 7 of this invention produces extremely good adhesion during the curing process, and it is possible to make a very strong bond between the cured cell wall material and the substrate. The contact printing method in claim 8 of this invention produces very good adhesion over the entire surface of the printing mold, and it is possible to make the bond between the cured cell wall material and the substrate extremely strong. The contact printing method in claim 9 of this invention can achieve complete release easily. The contact printing method in claim 10 of this invention can achieve complete perfect release easily.
[0061] The contact printing device in claim 11 of this invention can be used to form large, high definition parts with satisfactory quality easily since the printing mold is plastic enough to follow unevenness on the substrate. The contact printing device in claim 12 of this invention can attain complete adhesion over the entire area without

entrapping gas. The contact printing device in claim 13 of this invention can attain more perfect adhesion without entrapping gas. The contact printing device in claim 14 of this invention produces extremely good adhesion during the curing process, and it is possible to make adhesion between the cured cell wall materials and the substrate extremely strong. The contact printing device in claim 15 of this invention produces extremely good adhesion over the entire surface of the printing mold, and it is possible to make adhesion between the cured cell wall materials and the substrate extremely strong. The contact printing device in claim 16 of this invention uses a loop belt which is elastic and plastic as a pressure diffusing part, so extremely good adhesion is attained over the entire surface of the printing mold. The contact printing device in claim 17 of this invention uses an air bag which is expanded area introducing pressurized gas as a pressure diffusing part, and extremely good adhesion is attained over the entire surface of the printing mold. The contact printing device in claim 18 of this invention can attain complete release easily. The contact printing device in claim 19 of this invention attains complete release more easily and more completely.

(Simple explanation of figures)
Figure 1: one example of a printing mold of this invention.
Figure 2: one example of a manufacturing method for a printing mold or main mold body in this invention.
Figure 3: one example a contact printing device of this invention.
Figure 4: adhesion motion of a contact printing device of this invention.
Figure 5: another example of a work stand for the contact printing device of this invention.
Figure 6: one example of an exposing station for the contact printing device of this invention.
Figure 7: one example of an AC model PDP.
Figure 8: model of the adhesion process for a contact printing device of this invention.
Figure 9: model of the release process for a contact printing device of this invention.
Figure 10: 1st example of a contact printing device which minimizes pressure deviation by using a pressure diffusing part.
Figure 11: 2nd example of a contact printing device which minimizes pressure deviation by using a pressure diffusing part.

(Explanation of symbols in figures)
11: belt
12a, 12b, 12c,… :rollers
13a, 13b: air cylinders
14: roller support
20: air bag
21: belt
22a, 22b, 22c,…: back up rollers
23: air cylinder
24: adhesion roller
102: cushion layer
103: main mold body

104: concave part for forming cell walls
210: base electrode
220: conductive thin film
240: photo-sensitive resist layer
250: ionizing radiation
270: conductive thin film
280: electrolytic plating layer
301: work stand
302: adhesion stand
303: glass disk
304: light source for exposing
305: camera for detecting position
306: positioning roller
307: adhering roller
320: glass substrate
321: edge of printing mold
501: adhesion device (releasing device) disk
502: handling plate
503: seal
520: substrate to be printed
521: printing mold
710: glass substrate (front)
720: glass substrate (back)
730: cell wall (cell wall or rib)
740: transparent electrode
750: metal electrode
760: derivative layer
770: protection layer (MgO layer)
780: address electrode
790: fluorescent surface
801: filled printing mold
802: substrate to be printed
803: initial adhesion area
804: intermediate adhesion area
805: final adhesion area
806: linear release boundary
807: completed cell walls